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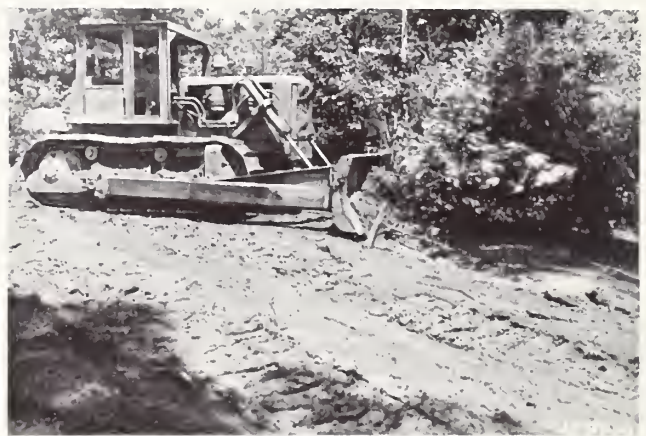
by

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# Site Treatment Reduces Need for Planting at Loblolly Harvest Time

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Intensive research for more than a decade has shown that natural regeneration of loblolly pine after commercial harvest is usually possible, and with planning usually successful, in the coastal plain of Virginia and the Carolinas.<sup>1/</sup> Nevertheless, poor seed years, difficult conditions, a desire to insure the reproduction of valuable stands, and various other reasons have of late years led a number of large landowners to try planting after harvest as a method of forest regeneration. The area (well stocked as a rule) is logged, in some cases it is disked or bulldozed, the hardwoods may or may not be poisoned, and then the nursery seedlings are planted by hand.

Because most of these plantations are as yet under 5 years of age, little has been known of the effectiveness of this method of regeneration. Whether such plantings are necessary has been something of a question too. Consequently, this paper reports an exploratory survey of 3-year-old plantations established in 1954-1955. It supplies some information and evaluates practices and factors that affect establishment and growth of planted seedlings, wildings, and the combined new stand.

## PLANTING HISTORY AND STUDY METHODS

Planting records for the 1954-1955 season on over 4,000 acres of forest land in seven Virginia counties south of the James River were obtained from three coastal plain pulp companies: Union Bag-Camp Paper Corporation, Continental Can Company, Inc., and Southern Johns-Manville Products Corporation. The plantations were on well drained to imperfectly drained lands. None were on the poorly drained flat lands typical of the eastern part of the coastal plain. Site index estimates ranged from 75 to 90 and averaged 83.

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<sup>1/</sup> Wenger, Karl F., and Trousdell, Kenneth. Natural regeneration of loblolly pine in the South Atlantic Coastal Plain. U. S. Dept. Agr. Prod. Res. Rpt. 13, 78 pp., illus. 1958.

Three preplanting treatments were studied: no ground preparation, disking before planting, and bulldozing before planting. Plantations established without ground preparation included lands planted on hardwood areas without previous logging, and areas logged before planting. The disking treatments were alike in that all areas were given a single disking rather than the more severe double disking used in later years. Eight of the bulldozed samples were on areas windrowed, while four were not. Hardwoods were generally poisoned except in the windrows on bulldozed areas, where they were inaccessible. Disked and bulldozed areas 4 years after planting are shown in figure 1.

Although all seedlings were bar planted, rate of planting differed with each company; one planted at a spacing designed to establish 800 seedlings per acre, another 900, and the third 1,000. The plantations were established under varying amounts of competition from large trees. Some large hardwoods were not deadened and some were treated but survived. Yellow-poplar was consistently left on all areas, and sweetgum was saved on one ownership. On all lands, residual pines were purposely left untreated; on some areas seed trees were left standing. Small hardwoods and pine were generally not chemically treated, and those trees surviving chemical treatments remained to grow.

Twelve random samples were drawn from plantations within each of the three treatments. Each random field sample consisted of a plot containing 100 milacres. On each milacre the seedlings were counted and classified as either planted or natural. The best prospect of each of these two classes was also classified as free-to-grow or not free-to-grow.<sup>2/</sup> In addition, the height of the tallest planted seedling was measured.

The root systems of planted seedlings were classed as good, L-shaped, J-shaped, or balled. Soil characteristics were related to planted seedling height according to the soil-site classification of Coile.<sup>3/</sup>

Free-to-grow stocking has previously been shown to be related to total stocking and hardwood competition.<sup>4/</sup> Competition 1 inch d. b. h. and larger of both pine and hardwoods was measured by point sampling with a wedge prism, and the pine was separated into two classes, cone bearers and non-cone bearers.

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<sup>2/</sup> "Free-to-grow" seedlings are seedlings which were not definitely overtopped at the time of measurement and whose height in relation to competing vegetation precluded overtopping during the next growing season.

<sup>3/</sup> Coile, T. S. Soil productivity for southern pines. Part I, Shortleaf and loblolly pines. Forest Farmer XI(7): 10, 11, 13. 1952.

<sup>4/</sup> See footnote 1.



Figure 1.—Above, Plantation at age 4 in Sussex County, Virginia. Area was logged, disked, planted, and hardwoods poisoned. Below, Plantation at age 4 in Chesterfield County, Virginia. Site was bulldozed, all hardwoods were windrowed, and area planted. Brushy area at right shows the margin of a windrow.



## RESULTS

### Treatments Had Little Effect on Survival and Development of Planted Seedlings

The tendency of planters to cluster and the presence of obstructions in the form of stumps and slash caused an irregular spacing of planted seedlings. Thus, the spacing of planted seedlings was unlike the regular pattern that characterizes most plantations, and only at the lowest numbers of surviving seedlings per acre did stocking approach regular spacing. The relationship of number of seedlings and their milacre stocking in figure 2 indicates the difficulty of obtaining a high percentage of milacre stocking of planted seedlings under forest conditions.

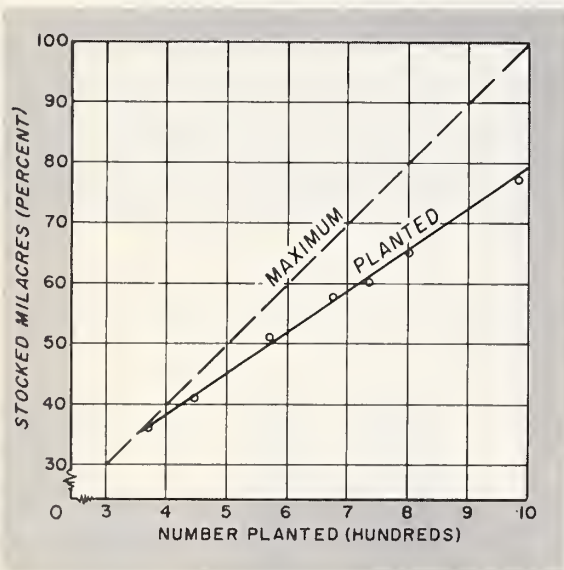


Figure 2.—The level of milacre stocking attained by planting, compared to maximum stocking attainable. Under forest conditions it is difficult to obtain a high percentage of milacre stocking of planted seedlings.

The basal area per acre of pine and hardwood trees 1 inch d. b. h. and larger provided a measure of competition. On the 36 harvested plots, competition varied between 1 and 39 square feet of basal area per acre. The average basal area of this competition was 22 square feet on areas logged without additional treatment, 19 square feet on disked areas, and 16 square feet on bulldozed lands. The effect of residual trees upon planted seedlings is to reduce the percentage of trees that are expected to attain dominance in the stand. On the eight bulldozed areas with windrows, this competition was principally in the windrows.

Variation in number of planted seedlings, in milacre stocking of planted seedlings, and in level of competition was found to be greater within treatment than between treatments. In fact, it appears that the basic treatments per se had little, if any, effect upon either survival or early development of the planted seedlings.

## Treatments Had Important Effect on Natural Seedlings

There was a positive correlation between number of natural seedlings and the basal area of cone-bearing pines per acre on all areas.

The larger number of natural seedlings found on bulldozed lands indicates that better and longer-lasting seedbed conditions are provided by this treatment. It was evident from the number of 1- and 2-year-old seedlings on bulldozed lands that seedbeds prepared by bulldozing are good seedbeds for at least 3 years. From other studies<sup>5/</sup> it has been determined that disked, logged, or burned seedbeds are good the first year but become poor seedbeds by the third year.

The best expression of factors influencing free-to-grow stocking of natural seedlings by milacres is:

$$\text{Free-to-grow stocking by milacres} = -2.195 + 1.064(S) - 3.191(B)$$

where S = total stocking by milacres

B = basal area of all trees 1 inch d. b. h. and  
larger, coded as follows:

0 to 5 sq. ft. basal area = 1; 5 to

10 sq. ft. basal area = 2; etc.

This expression accounted for 93 percent of the total variation.

## Total Seedling Stand

On the average, there were more natural than planted seedlings per acre (table 1). Naturally established seedlings ranged from 50 to 2,870 per acre, with nearly half the plots containing over 1,000 natural seedlings per acre.

Disking and bulldozing increased the total seedling stand and increased both the total and free-to-grow stocking. When planted seedlings were excluded and natural seedlings alone were tallied, the same held true. It is also true that there were fewer cone-bearing pines and a greater basal area of hardwood competition on logged plots with no other treatment than on disked or bulldozed plots.

Table 1.—Number of seedlings, and stocking 3 years after planting, by preplanting treatments

PLANTED SEEDLINGS			
Treatment	Per acre	Total	Free-to-grow
	Number	Percent of milacres stocked	
No treatment	536	48	36
Disked	648	55	46
Bulldozed	555	49	44
Average	579	51	42
NATURAL SEEDLINGS			
No treatment	551	26	19
Disked	688	39	31
Bulldozed	1,360	53	45
Average	866	39	32
ALL SEEDLINGS			
No treatment	1,087	62	47
Disked	1,336	71	59
Bulldozed	1,915	72	63
Average	1,445	68	56

<sup>5/</sup> See footnote 1.

The most noticeable difference between treatments was the large number of natural seedlings found on bulldozed lands. This superiority of bulldozed sites for natural regeneration is a fact of far-reaching economic importance to forest landowners now carrying out large planting programs.

Only one of all the stands in this study contained less than 700 seedlings per acre--both planted and natural--and one was below 50 percent milacres stocked. If 40 percent free-to-grow stocking is considered adequate, 31 out of 36 plantations were adequately stocked by a combination of naturally established and planted pine. The plantations which failed to reach 40 percent free-to-grow stocking were not confined to any single treatment.

Thus, within the range of total stocking encountered in this survey (averaging 68 percent, with none below 47 percent), the success or failure of plantations was dependent upon the control of competition. Although some of the competition was pine and yellow-poplar left to seed the plantations or to grow, an efficient cultural operation eliminating the overtopping cull hardwoods would bring the free-to-grow stocking in all plantations above 40 percent by milacres.

The average free-to-grow height, the height of the tallest 20 percent, and the average seedling height on dry and wet sites were analyzed in relation to site index and treatment, and failed to show any growth trend associated with these variables.

Field personnel observed that deep planting in relatively wet areas greatly reduced root development and height growth; also, honeysuckle on good sites reduced height growth of pine seedlings; and the windrowed area containing the shortest seedlings was flat, contained residual pond pine, and apparently had been puddled by heavy mechanical equipment.

### Root Systems of Planted Pines

Over 2,000 root systems of planted seedlings were classified according to the form of the taproot. Compressed by bar planting, these root systems could readily be distinguished from the symmetrical root systems of natural seedlings.

The typical good roots had a vertical taproot. The typical J-shaped root system had the tip of the taproot pointed towards the soil surface. The taproot in the L-root classification was pointed horizontally, and the balled roots had the taproot and laterals twisted together in an indistinguishable mass. Classes other than "good" included all kinds of twisted roots, and assignment to these classes was necessarily arbitrary. The most misshaped root system was the balled class, the J was less misshaped, and the L-root system resembled somewhat the drag-root system resulting from machine planting. Only 33 percent of the roots had good form (table 2 and figure 3).

The percentage of deformities in root systems was not related to treatment or planting organization. It appeared that the deformed root systems were a result of faulty planting technique, which was not restricted to any area, treatment, or organization.



Figure 3.—A comparison showing natural seedling root systems on the left and deformed planted root systems on the right. About two-thirds of the planted roots were classed as deformed or misshapen.

Table 2.—Form of taproot (percent of total)

Treatment	Taproot classification			
	Good	L	J	Balled
	----- Percent -----			
No treatment	35	10	35	20
Disked	32	10	34	24
Bulldozed	30	13	37	20
Weighted average	33	11	35	21

Also, many seedlings were planted deep. Deep planting restricts root development on wet or imperfectly drained soils and hinders normal growth. Many deep-planted seedlings encountered in the survey on wet sites were short and had little chance in competition with native vegetation. The effect of deep planting should be evident at an early age, as the plant either grows well or falls behind and dies.

A poorly arranged root system is likely to have a longer-lasting influence on growth and survival than does depth of planting. Although there was little opportunity in this survey to determine early mortality, an occasional upturned seedling was noted, and in each such case the root system was balled and had no lateral root support on one or more sides. There is, of course, danger that other seedlings will upturn because of inadequate support. Observations elsewhere have shown that root systems of planted yellow pines can be attacked by *Fomes annosus* following thinning operations. It would thus seem advisable to try for normal root arrangement to lessen the danger of both overturn and infection. There is a real need for additional research on both the short- and long-term effect of depth of planting and root arrangement as related to site.

It is suspected that planting procedures were similar for each company, as the planting depth and percent of misshapen roots were about the same for each. It is also suspected that planters failed to follow the complete step-by-step operations recommended for bar planting. <sup>6/</sup>

A failure to shake the seedling and to straighten roots by raising the root collar to the soil surface should not decrease first-year survival, and on droughty sites the resulting deep planting may increase survival. For this reason, improper depth of setting and failure to adjust roots by shaking is not apparent until the plant is lifted.

The necessity for training and supervising planting crews is stressed in planting literature. With the presently expanded planting programs, many temporary company and contract crews are operating during the relatively short planting season. It is sound economics to spend whatever is necessary to insure that the seedlings are firmly set to avoid mortality from drought, that the seedlings are planted to the depth desired, and that the root systems are placed in a somewhat normal arrangement. To provide adequate supervision, the foreman or forester in charge must have definite planting specifications, and he must repeatedly check each individual planter for compliance. It is not unreasonable to expect the foreman to check for firmness of planting, planting depth, and root arrangement of the trees planted under his supervision.

<sup>6/</sup> Wakeley, P. C. Planting the southern pines. U. S. Dept. Agr. Monog. 18, 233 pp., illus. 1954.

## DISCUSSION

### Planting Was Often Unnecessary

It was impossible to determine survival percent under conditions of this study, since individual seedlings were not staked out at the time of planting.

Survival of planted pines and their growth into position estimated as free-to-grow was apparently not related to preplanting treatments. What preplanting treatments did was to reduce competition and create conditions that favor natural regeneration. When competition was measured for each treatment independently, the major effect of treatment was to influence the number of natural seedlings that became established. The planted areas examined were all on forest land, and regeneration of one sort or another began when stands were destroyed by logging, hardwood control, or mechanical treatment. Hardwood root stock sprouted, and hardwood and pine seedlings became established. Under these conditions the planting operation must be evaluated by its effect on improvement of free-to-grow stocking.

Table 3.— Free-to-grow stocking of natural loblolly pine, free-to-grow stocking added by planting, and total free-to-grow stocking under various treatments

Treatment	Stocking of natural seedlings	Stocking added by planting	Total stocking
----- Percent -----			
No treatment	19	28	47
Disk	31	28	59
Bulldoze	45	18	63
Average	32	25	56

Planting did not improve the spacing of trees; and only on some windrowed, bulldozed plots was planted reproduction noticeably taller than natural reproduction. Planting did, on each plot, increase the free-to-grow stocking (table 3). At one extreme, a natural stand of 19 percent free-to-grow stocking was increased to 76 percent by planting; at the other extreme, the natural stand was 69 percent free-to-grow stocked, and planting increased the total free-to-grow stocking to 77 percent.

Oddly enough, the mechanical treatments to prepare the land for planting, by creating conditions favorable to natural reproduction, made planting less necessary.

### Dollars and Cents

These data can be used in economic analyses. As an illustration: if planting costs \$10.00, mechanical treatments \$10.00, and hardwood control \$5.00 per acre, then (a) planting and poisoning treatment costs \$15.00; (b) bulldozing and planting \$20.00; and (c) disking, planting, and poisoning \$25.00. Using the increased stocking resulting from planting, there were 280 free-to-grow planted trees on nontreated and on disked areas, and 180 free-to-grow planted pines per acre on the bulldozed lands. The cost of each free-to-grow planted seedling thus becomes: (a) 5.4 cents, (b) 11.1 cents, and (c) 8.9 cents.

Another economic consideration might be the influence of disking and bulldozing on milacre establishment of free-to-grow naturals and planted pine. According to table 3, there were 470 free-to-grow pines per acre with no ground preparation. Following disking there were 590 per acre, and following bulldozing 630. It might be concluded that disking alone increased free-to-grow stocking by 120 seedlings per acre, and bulldozing by 160 per acre. If \$10.00 is accepted as a cost for ground preparation, then seedlings added by disking cost 8.3 cents apiece, and each seedling added by bulldozing cost 6.2 cents.

The advisability of removing competition can be approximated from figure 4 if poisoning costs are known. About 6 percent increase in free-to-grow stocking should result for the reduction of each 10 square feet of basal area of competition. On at least three plantations where the stand was not cut, the planted pine would have been entirely suppressed without a hardwood control job. The reduction of established competition is essential for both natural and planted seedlings.

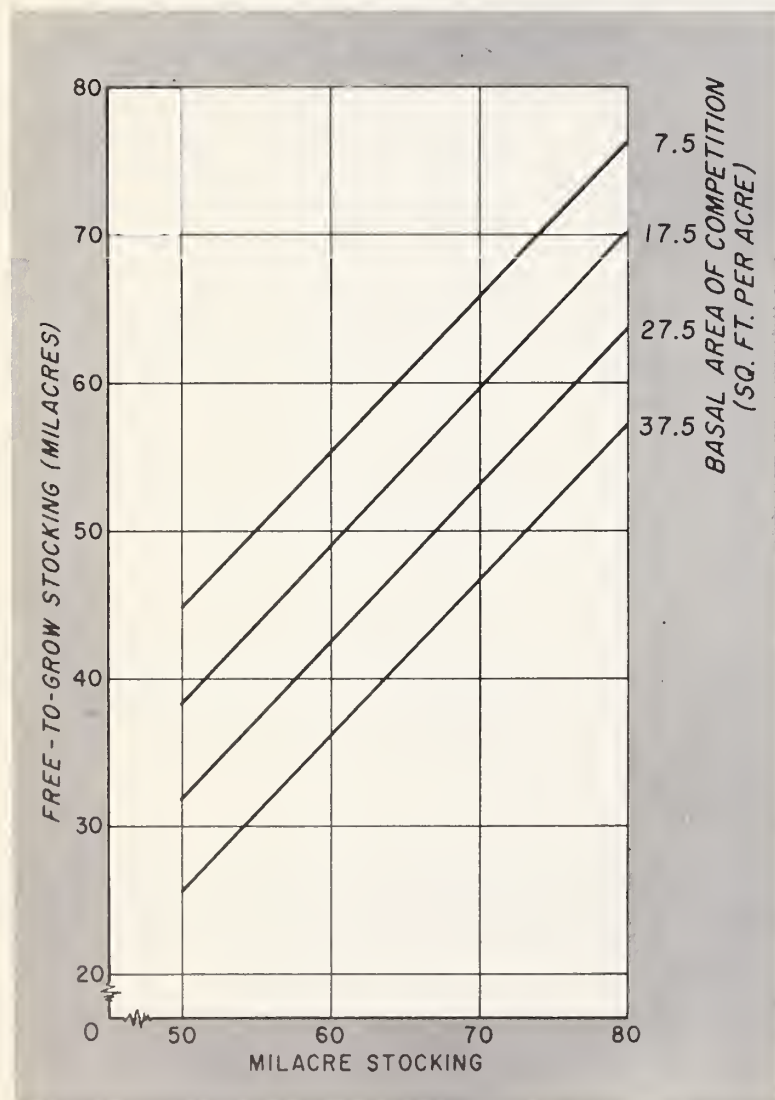


Figure 4.—Free-to-grow stocking related to total stocking and competition.

## SUMMARY

Loblolly pine plantations made on recently harvested forest lands in 1954-1955 were studied following each of three preplanting methods: disking, bulldozing, and no treatment. The number of both planted and natural pines after three years in the field was determined, as well as the percent milacre stocking. Height and class of root system for planted pines were recorded.

Reproduction on each plot consisted of planted pines, natural pines, and hardwood sprouts and seedlings. Larger competition of both pine and hardwood trees overtopping reproduction was the least on bulldozed lands and the most on lands that had no ground preparation. The reduction of established competition is essential for both natural and planted seedlings.

Examination of existing coastal plain loblolly pine plantations tends to be misleading because obstructions such as stumps and windrows make the spacing irregular, and wildings, which can scarcely be distinguished from planted seedlings may comprise a majority of the stand.

Three years after planting, there were 579 planted pines per average acre, and these produced stands 51 percent stocked by milacres. However, 14 of the 36 plantations contained over 1,000 natural seedlings per acre and, on the average, there were more natural than planted seedlings. More natural seedlings occurred on bulldozed than on either disked or nontreated areas. On the basis of planted pines solely, half the plots would be considered failures if 40 percent free-to-grow is the lowest stocking acceptable.

The combined pine reproduction averaged 1,445 seedlings per acre, 68 percent stocked, and 56 percent stocked free-to-grow. All the plots could be raised to 40 percent stocked free-to-grow by treatments designed to reduce competition. On bulldozed lands, the seedlings that came in naturally stocked 53 percent of the plots adequately. The most noticeable difference between treatments was the large number of natural seedlings found on bulldozed lands.

This study confirms many research reports on natural regeneration of loblolly pine following harvest in the coastal plain; as those reports pointed out, loblolly pine regenerates naturally provided seed trees are adequate, harvest takes place in a moderately good seed year, soil is scarified, and hardwoods are controlled. The additional stocking occasioned by planting is indeed costly in terms of increased stocking. Assuming hardwood control for all but the bulldozed treatments, each additional free-to-grow planted seedling cost 5.4 cents with no ground preparation, 8.9 cents with disking, and 11.1 cents with bulldozing. Two-thirds of these expensive seedlings had misshapen root systems which could handicap future growth.

